SYNTHETIC SUBSTITUTES IN AGRICULTURAL MARKETS

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Synthetic products and raw materials are replacing some agricultural raw materials in both food and nonfood markets. This is not new and can be expected to continue due to changing technology, consumer preferences, tastes, and incomes. As consumer demands change, technical developments in product processing and formulation may also change. In some cases, these changes result in the substitution of synthetics for agricultural products and raw materials. In this article, 6 markets are used to illustrate the rate and magnitude of synthetic substitutes on the use of agricultural products and raw materials.

What is a synthetic?

In technical terms, a synthetic is a product or compound produced by artificial means rather than occurring in natural form. Thus, a synthetic can be derived from either agricultural or nonagricultural raw materials. However, in this article, we are primarily concerned with synthetics from nonagricultural raw materials versus agricultural commodities regardless of the amount of processing. Products that may be synthesized from agricultural materials are not considered synthetic for the purpose of this article. For example, ethylene glycol (antifreeze) is a synthetic derived from nonagricultural sources, whereas fatty acids and rayon are derived from agricultural raw materials.

Effects of Synthetic Substitutes on Agricultural Markets

Synthetic substitutes affect markets for agricultural products in several ways. The most evident effect is to slow the consumption of competing agricultural products. This leads to an alteration in market shares and the market value of agricultural products relative to synthetics. The second and most relevant effect is the impact synthetic substitutes have on the market value of agricultural products. Also these changes may alter the distribution patterns of income flows that traditionally accrue to specific commodity groups and agricultural marketing firms. This article explores market growth rates and market shares using 6 agricultural markets as examples. The measurement of the impact of synthetics on the market value of agricultural products is an objective of a research project underway in the Department.

Growth Rates, Market Shares, and Prices of Agricultural and Synthetic Materials in Selected Markets

Agricultural products compete with synthetic substitutes in many markets. For this reason, only a few end-use markets are used to illustrate differences in annual growth rates, changes occurring in market shares, and the underlying price relationships. Growth rates and changing market shares indicate the direction and approximate magnitude of the impact of synthetics on the use of agricultural products. The prices, as shown here, reflect only one aspect of the competitive relationships existing between agricultural and synthetic products and raw materials. Differences in physical characteristics and functional performance in each end-use market also influence the use of synthetic and agricultural materials. However, the affects of these factors are not analyzed in this article.

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Fiber markets 2/: Fibers are usually classed as cellulosic and noncellulosic. 3/ Therefore, this classification is used here as a basis for presenting the impact of synthetic (noncellulosic) fibers on the market for fibers derived from agricultural sources.

Domestic utilization of all fibers has increased at an annual rate of 3 percent since 1949 (table 12). The use of synthetic fibers has increased at an annual rate of 19 percent compared with less than 1 percent for the agricultural fibers. The magnitude of these growth rates suggests an increase in the per capita consumption of noncellulosic fibers and a decrease in per capita consumption of cellulosic fibers.

Table 12.--Fiber market: Annual growth rate in consumption, market share, and prices of cellulosic and noncellulosic fibers

Type of fiber	Growth rate (1949-65)	Market share		Price per pound	
		1949	1965	1953	1965
	Percent	Percent	Percent	Cents	Cents
All fibers	2.8	100.0	100.0	---	---
Cellulosic	.4	97.2	67.2	1/32.3	1/28.1
Noncellulosic	19.0	2.8	32.8	2/92.0	2/53.4

1/ Average price per pound of cotton lint.
2/ An unweighted average annual price of selected nylon, acrylic and polyester staple fiber and tow converted to a cotton equivalent price by using a conversion factor of 1.74. Prices on noncellulosic fibers were not reported prior to 1953.

The market shares of cellulosic and noncellulosic fibers underwent a dramatic change during 1949-65. Cellulosic's share of the market fell from 97 percent in 1949 to 67 percent in 1965, whereas noncellulosic's share increased from 3 to 33 percent.

Synthetic fibers have increased in market share, although their composite price exceeded the price of cotton fiber during 1953-65. However, the price of synthetic fibers has declined in recent years while cotton prices remained relatively stable.

2/ Data for this market compiled from: Supplement for 1962 to Statistics and Related Data, 1925-1962, S. B. No. 329, Economic Research Service, USDA, 1965: Wool Statistics and Related Data, 1920-1964, Supplement for 1964, S. B. No. 364, Economic Research Service, USDA, 1965.

3/ Cellulosic fibers include cotton, wool, and rayon. Technically, wool is not a cellulosic fiber but is so classified here for expository purposes only. Also included from cellulosic fibers are the imported vegetable fibers such as jute, sisal, etc. Noncellulosic fibers include nylon, polyester, glass, and other man-made fibers. For comparison purposes, all fibers were converted into cotton equivalent. For explanation of conversion factors, see reference cited in footnote 2.

Soap and detergent market 4/: The soap industry has traditionally been a large consumer of animal fats and vegetable oils. Technological changes and shifts in consumer and industrial demand for soaps and detergents have resulted in a decline in the use of fats and oils and an increase in the use of synthetic raw materials (table 13). The growth rate of raw materials used in the soap and detergent industries increased 3 percent annually during 1945-65. The growth rate for agricultural raw materials declined 6 percent annually while the use of synthetic materials increased 17 percent. As a consequence, agriculture's share of the soap and detergent market declined from 96 percent in 1945 to 19 percent in 1965.

Table 13.--Soap and detergent market: Annual growth rate, market share, and prices of agricultural and nonagricultural materials used in production of soaps and detergents

Type of material	Growth rate (1945-65)	Market share		Price per pound	
		1945	1965	1952	1965
	Percent	Percent	Percent	Cents	Cents
All materials	3.4	100.0	100.0	---	---
Agricultural	-5.9	96.3	19.3	1/5.0	1/9.1
Nonagricultural	17.0	3.7	80.7	2/13.4	2/10.3

1/ Weighted average price of animal fats and vegetable oils used in the soap industry.
2/ Average price of dodecylbenzene. Prices not reported prior to 1952.

The growth rate and market share figures shown in table 13 should be viewed as approximations because of the difficulty in converting detergent sales data into a comparable agricultural raw materials base. A ratio of annual soap sales to the amount of agricultural raw materials used in soaps was used to convert detergent sales into equivalent amounts of agricultural materials. This conversion procedure assumes a 1 to 1 substitution ratio between agricultural and synthetic raw materials used in soap and detergent production and that production equals sales.

Since 1952, the price of dodecylbenzene, a synthetic used in detergents, has trended downward, whereas the price of agricultural materials has increased slightly. The declining price of dodecylbenzene is only one factor affecting the replacement of agricultural raw materials by synthetics. Factors such as differences in product formulation, wetting properties, foaming characteristics, and availability of other synthetic raw materials also influence the use of agricultural raw materials.

4/ Data for this market compiled from: Agricultural Statistics, 1966. USDA; U.S. Fats and Oils Statistics, 1909-1965, S. P. No. 326, Economic Research Service, USDA, 1966; Wholesale Prices and Price Indexes, Bureau of Labor Statistics, U.S. Department of Labor, and various issues of Oil, Paint, and Drug Reporter.

Ethyl alcohol market 5/: Ethyl alcohol is produced from agricultural raw materials containing carbohydrates and from ethylene gas, a synthetic material. Available ethyl alcohol production statistics are divided into two classes, natural and synthetic. These data were converted into agricultural raw material equivalents by assuming that 1,000 gallons of ethyl alcohol could be obtained from 372 bushels of corn and 83 bushels of barley malt. This procedure probably underestimates the amount of raw materials used since various agricultural and synthetic raw materials yield differing amounts of ethyl alcohol.

The use of all raw materials for ethyl alcohol production increased at an annual rate of 4 percent during 1946-65. Synthetic raw materials increased 8 percent and agricultural raw materials declined at an annual rate of 6 percent (table 14). As a result, agriculture's share of this raw material market declined from 61 percent in 1946 to 16 percent in 1965.

Table 14.--Ethyl alcohol market: Annual growth rate, market share, and prices of agricultural and nonagricultural materials used in production of ethyl alcohol

Type of material	Growth rate (1946-65)	Market share		Price per pound	
		1946	1965	1946	1965
	Percent	Percent	Percent	Cents	Cents
All materials	4.0	100.0	100.0	---	---
Agricultural 1/	-6.2	61.3	16.2	5.1	2.2
Nonagricultural 2/	8.4	38.7	83.8	5.0	4.8

1/ Barley and corn.
2/ Ethylene gas.

Corn and barley prices [illegible], whereas, the price of ethylene gas remained about 5 cents per pound. However, ethylene gas [illegible] materials in alcohol production. [illegible] is only one raw material component [illegible] ethylene gas must be evaluated in terms of total raw material [illegible] other raw materials are also required [illegible].

5/ Data for this market compiled [illegible]: [illegible]. U.S. Tariff Commission, annual reports 1946-65; [illegible]. [illegible]: Tobacco Summary Statistics, U.S. Treasury Reports [illegible], Internal Revenue Service, fiscal years 1945-65.

Sweetener market 6/: Saccharin and cyclamates compete with cane and beet sugar in foods and beverages. For comparison of growth rates, market shares, and prices, saccharin and cyclamates are converted to sugar sweetness equivalents. 7/

The consumption of cane and beet sugar, on a refined basis, increased 1.6 percent annually during 1958-65, about in line with the increase in population. The consumption of saccharin and cyclamates, starting from a much smaller base, increased 9 percent annually (table 15). Cane and beet sugar's share of the market declined from 96 percent in 1958 to 94 percent in 1965.

Table 15.--Sweetener market: Annual growth rate of consumption, market share, and prices of agricultural and nonagricultural sweeteners

Type of sweetener	Growth rate (1958-65)	Market share		Price per pound	
		1958	1965	1958	1965
	Percent	Percent	Percent	Cents	Cents
All sweeteners	1.9	100.0	100.0	---	---
Agricultural 1/	1.6	96.3	93.8	6.3	6.9
Nonagricultural 2/ ...	9.3	3.7	6.2	3/7.1	3/1.0

1/ Includes only cane and beet sugar.
2/ Includes saccharin and cyclamates. Saccharin and cyclamates were converted to sugar equivalents by using a 300 to 1 and 30 to 1 ratio respectively.
3/ Weighted average price of saccharin and cyclamates converted to a sugar equivalent.

The price of synthetics trended downward during 1958-65, due mostly to a sharp decline in cyclamate prices. Cyclamate prices, in terms of sugar sweetness equivalents, dropped from 9 to 3 cents per pound while saccharin remained near ½ cent per pound. The average price of cane and beet sugar was 4 percent higher in 1965 than in 1958 and remained higher than synthetic sweetener prices during the period.

6/ Data for this market compiled from: Agricultural Statistics, 1966. USDA; Sugar Reports, Agricultural Stabilization and Conservation Service, USDA, 1958-65; Ballinger, Roy A., Non-Caloric Sweeteners: Their Position in the Sweetener Industry; AER No. 113, Economic Research Service, USDA, 1967; Gray, Frederick D., The Sweetener Market--Trends and Prospects, Economic Research Service, TWA-267, USDA, 1965.

7/ For an explanation of the conversion ratio used, see: Ballinger, Roy A., Non-Caloric Sweeteners: Their Position in the Sweetener Industry. AER No. 113, Economic Research Service, USDA, p. 4, 1967.

Oilseed protein feed market 8/: Urea is an organic chemical which can be substituted for high protein agricultural materials--especially the oilseed meals--used in feeds prepared for ruminant animals. In this analysis, a comparison is made between oilseed protein meals fed to beef cattle, dairy cattle, sheep, and urea used in feeds. The total use of oilseed meals and urea in feeds has increased 6 percent annually since 1955 (table 16). Individually, oilseed meals increased 6 percent and urea 10 percent. The market share of oilseed meals declined from 91 percent to 88 percent from 1955 to 1964.

Table 16.--Oilseed protein feed market: Annual growth rate in consumption, market share, and price of oilseed meal and urea

Type of feed	Growth rate (1955-64)	Market share 1/		Price per pound 1/	
		1955	1964	1955	1964
	Percent	Percent	Percent	Cents	Cents
All feeds	6.3	100.0	100.0	---	---
Oilseed meal 2/	5.8	91.3	87.8	2.6	3.6
Urea 2/	10.4	8.7	12.2	3/1.0	3/1.0

1/ Year beginning in October for oilseed meal, calendar year for urea.
2/ Converted to a 44-percent soybean meal equivalent.
3/ A factor of 5.36 was used to convert urea prices into equivalent protein in soybean meal. This factor does not allow for the carbohydrate value of the soybean meal or the carbohydrate that would be required in grain-urea mixtures.

The urea price is lower than oilseed meal prices on an equivalent protein basis. However, there is a technical limitation on the amount of urea that can be used in mixed feeds, and urea is used only in ruminant feeds. These limitations on the use of urea appear to limit the impact it will have on the market for oilseed meals in feeds.

Glycerin market 9/: Natural glycerin is a byproduct of animal fats and vegetable oils used in soap manufacturing, fat-splitting operations, and fatty acid manufacturing. Since natural glycerin is not produced as a primary product, no attempt is made to convert natural and synthetic glycerin production into equal units of raw materials. A direct comparison is made between natural and synthetic glycerin production to indicate the impact of synthetics on the glycerin market.

Total glycerin production increased at an annual rate of 5 percent, synthetic at 13 percent, and natural declined 1.5 percent during 1955-64 (table 17). The market share of natural glycerin declined from 90 percent in 1955 to 65 percent in 1965 due to a reduction in the use of animal fats and vegetable oils [illegible].

8/ Data for this market compiled from: Agricultural Statistics, 1966, USDA; Feed Situation, Economic Research Service, USDA, 1958-65; Synthetic Organic Chemicals, U.S. Tariff Commission, annual reports 1958-65.
9/ Data for this market compiled from: Agricultural Statistics, 1966, USDA; Synthetic Organic Chemicals, U.S. Tariff Commission, annual reports 1958-65.

Table 17.--Glycerin market: Annual growth rate in production, market share, and prices of natural and synthetic glycerin

Type of glycerin	Growth rate (1945-65)	Market share		Price per pound 1/	
		1945	1965	1953	1965
	Percent	Percent	Percent	Cents	Cents
All glycerin	3.1	100.0	100.0	---	---
Natural	-1.5	89.7	42.8	27.4	13.1
Synthetic	13.0	10.3	57.2	29.7	18.5

1/ Converted to an 80 percent soaplye basis. Price of synthetic glycerin not reported prior to 1953.

Prices of both natural and synthetic glycerin declined during 1953-65. However, prices of synthetic glycerin remained slightly above natural glycerin during the entire period and the margin between the two prices remained stable.

These 6 markets illustrate the inroads synthetics have made in traditional agricultural markets. Competition between agricultural products and synthetics is not limited to these markets. Agricultural products also are being replaced by synthetic materials in the manufacture of shoes, protective coatings, perfume and flavors, pharmeceuticals, plastics, and paper.

The technical and economic factors influencing the replacement of agricultural products by synthetics, other than price, are not presented in this article. An evaluation of these factors is being made under a research project now in progress in the Department.

Market Adjustments to Meet the Challenge of Synthetics

Two approaches to the problem of improving the competitive position of agricultural products relative to synthetics are being actively pursued. These are new product development and development of new and improved processing techniques. Usually a combination of these techniques is used by agricultural producers, processors, and marketing groups, and by private and public agencies.

New product development: Many new or improved agricultural products have been developed to meet the specialized demands of consumers and industrial users. Product improvements range from an alteration of the physical appearance of the commodities to packaging to chemical synthesis that enhances their performance in end-products. Several new consumer products are stretch cotton fabrics, freeze-dried foods, low fat milk, boil-in-the-bag vegetables, aerosol-packed cheese spreads, concentrated fruit beverages and powders, sweetpotato flakes, and permanent press apparel. Progress has also been made in the development of new products for industrial use. Some examples are dialdehyde starch for improving the wet strength of paper, epoxidized soybean oil for use as plasticizers, and emulsifiable linseed oil for use in water emulsion paints. These new industrial products were developed to meet the changing physical and functional needs of industrial users and to place agricultural products in a more favorable competitive position relative to potential synthetic substitutes.

New processing techniques: New processing techniques have been designed to improve quality, reduce processing costs, and alter the physical and chemical properties of agricultural raw materials to better meet the demands of consumers and industrial users. Some recent examples are resin treatment for durable flame resistant cotton finishes, glutaldehyde tanning to improve leather flexibility, wool wurlanizing to attain washable woolen fabrics, and ozonolysis of fats and oils to obtain new derivatives for use in plastics and waxes.

Future Impact of Synthetics on Agricultural Markets

The basic agricultural commodities will face limited displacement as primary sources of food products in the immediate future. However, many of those commodities will be marketed as "engineered," "simulated," "fortified," or "fabricated" food products designed for specific market segments. Some examples are diet foods, enriched cereals, "meatless" meats, and convenience foods.

Agricultural products will have increased competition from synthetics in the nonfood markets. The trend in these markets is to use raw materials having relatively stable supply and price structures, specialized functional characteristics, and specific chemical and physical properties.

In several nonfood markets, further decreases can be expected in agriculture's share of the market. Examples are glycerin and drying oils. The total demand for glycerin is increasing while production of natural glycerin is declining. The demand for natural drying oil for use in paints is declining while production of paints is increasing. For glycerin, the decline of agriculture's market share is due to decreased production. For natural drying oils, the decline is due to technical changes occurring in the paint industry. Similar market changes are expected to occur in other nonfood markets as new processing techniques and new differentiated products are developed which do not require the use of agricultural raw materials.

The effect of synthetics will not be evenly distributed among the various agricultural commodities. For example, natural fibers are more susceptible to [illegible] than wheat flour. This is because synthetic fibers may serve the same basic functional needs as natural fibers, whereas no synthetic product has been commercially developed that functions as a complete food nutrient.

The future impact of synthetics on agricultural markets will probably depend a great deal on technological developments and changing consumer demand for food and nonfood products. However, the fact that about 75 percent of domestic agricultural marketings are for foods appears to limit the effect of synthetics on the [illegible] volume of agricultural marketings.